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ARSENICAL CATTLE DIPS:

METHODS OF PREPARATION AND DIRECTIONS FOR USE.

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INTRODUCTORY.

This bulletin is intended to be a handbook for the user of arsenical cattle dips. It aims to include in brief but ample form general information, formulas, tables, and practical hints bearing on the preparation and management of arsenical dipping solutions. But to this field it is strictly limited. Those who desire a popular account of the life history of the Texas-fever tick and of its relation to cattle are referred to a previous bulletin (Farmers' Bulletin 498) issued by the department. The same, as well as another previous publication (Bureau of Animal Industry Circular 207), contains plans and specifications for the construction of dipping vats, together with directions for the management of cattle in connection with dipping.

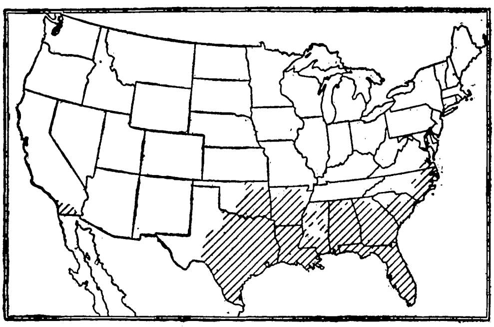

Fig. 1.—Map of the United States, the shaded area showing the territory to which this bulletin applies.

PROPERTIES OF SUBSTANCES USED IN MAKING DIPS.

Making a dip is simply a manufacturing proposition. No manufacturer can expect to get the best results unless he is somewhat acquainted with important facts regarding his raw materials.

White arsenic, also known as arsenic trioxid, arsenious or arsenous oxid or anhydrid, should always be purchased in the form of a fine powder, and under a guaranty of 99 per cent purity. Water, even when boiling, will dissolve only a little of it, and that slowly, but by the use of certain other chemicals white arsenic may be readily and abundantly brought into solution.

White arsenic is a violent poison, and users of it must never allow familiarity to beget carelessness. It may be absorbed into the system and cause injury or death, either through the mouth, the

lungs, or the skin; therefore neither the dry powder nor the solution should be allowed to remain on the skin. The breathing in of dust arising from the dry powder during handling must be avoided, while, if cattle are being sprayed, neither the operator nor the cattle should inhale any of the spray. Moreover, from a boiling solution arsenic may be thrown out as a fine spray and also, under certain conditions, as the very poisonous gas "arsin." Hence, concentrated dips should be prepared only in thoroughly ventilated places, while all work should be done on the windward side of the kettle and as far from it as practicable.

If arsenic in any form has been swallowed, medical attention is to be obtained as soon as possible; but since promptness of action is of very great importance and medical attention is not always readily available, it is best for all who use arsenical dips to be familiar with first-aid treatment. The United States Dispensatory (nineteenth edition) has the following to say in this matter:

> If the antidote * * * be not directly at hand, free vomiting should be induced by the finger, the feather part of a quill, and the administration of an emetic; * * * Demulcent drinks should be freely given, such as milk, white of eggs and water, or flour and water, which serve to encourage the vomiting and to envelop the poison.
>
> The antidote having been faithfully applied, the subsequent treatment consists in the administration of mucilaginous drinks and the treatment of symptoms as they arise.
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> * * * * * * *
>
> The antidote above referred to is * * * *ferric hydroxid with magnesium oxid in the moist or pulpy state.* As soon as it is ready it must be given in doses of a tablespoonful to an adult, of a dessertspoonful to a child, every five or ten minutes until the urgent symptoms are relieved. * * * Its efficacy is, of course, greater the sooner it is administered after the ingestion of the poison; but even after delay its use will prove advantageous so long as any portion of the poison still remains in the stomach. * * * It should be an invariable rule to prepare the antidote at the time it is wanted from materials always kept at hand. * * * The best antidote known is the combination of ferric hydroxid with magnesium oxid now recognized by the U. S. Pharmacopœia.

The materials for the antidote referred to can be supplied by any prescribing pharmacist, contained in two bottles. In this separated form the antidote keeps well, and when an emergency calls for its use all that is necessary is to mix thoroughly the contents of the two bottles and to administer as directed. But in any case medical attention must be obtained as soon as possible.

Sodium carbonate.—Also known as sal soda or washing soda, when fresh consists of colorless transparent crystals. On keeping, unless tightly closed from the air, it tends to lose its crystalline appearance and to fall to a white powder. This change is due merely to the fact that the crystals carry a large amount of combined water (water of crystallization), and on exposure to the air

much of this water may evaporate with consequent destruction of the crystalline form. The soda itself is in no way affected by this loss of water, except that it really becomes stronger, weight for weight.

Another form of sodium carbonate, called "monohydrated sodium carbonate," also occurs in commerce in the form of a white crystalline granular powder. It contains only a small amount of water of crystallization and is practically unaffected by exposure to air. This form of soda from a manufacturing point of view is far preferable to sal soda, as it is of constant and permanent composition, and being much stronger, weight for weight, it is less expensive to handle. When using monohydrated soda it is necessary to remember that only 4½ pounds are needed to do the same work as 10 pounds of sal soda.

Pine tar.—Pine tar when fresh is semiliquid, but with age becomes granular and nearly solid, in which condition it is of less value. Mixed with it is always more or less water of decidedly acid properties (pyroligneous acid), which on standing tends to float on the surface and should be dipped or poured off before the tar is used.

Tar is heavier than water and when stirred with it usually forms a very poor mixture from which most of the tar rapidly settles out, but when the water is of just the right temperature and somewhat alkaline a fairly stable suspension may generally be obtained. When previously treated with an amount of caustic alkali sufficient to combine with a considerable proportion of the tar acids, or when blended with soap, the tar easily mixes with water and then forms a good and permanent emulsion.

Caustic soda.—Also known as sodium hydroxid, or sodium hydrate, on account of its wide range of application by chemists, pharmacists, and manufacturing industries occurs commercially in a number of different forms, as powder, flakes, solid masses, or broken fragments; in color ranging from pure white to grayish or brownish tints. For the use of chemists and pharmacists it is put up in glass bottles; for industrial purposes it is supplied in various sized cans or drums of thin sheet iron. The latter is the variety that should be purchased for making dip. Its large output and wide use render it easily obtainable almost everywhere—far more so than white arsenic. The 10-pound can is the best size to buy for home use in preparing dips; larger consumers can probably handle the material in larger drums conveniently and of course more economically. The purchaser must make sure that the contents of the drum he contemplates buying are in fragmentary form, or granulated, for much caustic soda is run into drums in a melted condition and on cooling forms a single solid cake, which, though satisfactory for factory use, is not adapted for the present purpose. It should always be purchased under a guaranty of not less than 85 per cent actual caustic soda.

Caustic soda is an intensely active and powerful substance. When exposed to the air it strongly attracts moisture, increasing in weight and becoming pasty, while at the same time it becomes contaminated with sodium carbonate through absorption of carbon dioxid. Hence it must always be purchased in original containers, never in bulk; the container must not be opened until just before the material is to be used; the substance must not be allowed to stand exposed to the air, and if any is left over which is to be kept for subsequent use it must be immediately transferred to a tin pail provided with a tightly fitting cover, such as a lard pail, or, best of all, a paint pail with a friction top.

Owing to the intense chemical activity of caustic soda it is extremely corrosive in its effect upon skin or clothes, and upon the lungs if dust from it is inhaled. Therefore it is necessary to handle it gently to avoid the raising of dust and to wash off at once with water any which may touch the skin or clothing.

Caustic potash.—Also known as potassium hydroxid or hydrate, is very similar in its properties to caustic soda. It is not, however, so widely used industrially, and is decidedly more expensive without being any better for the present purpose. Therefore it should be purchased only when caustic soda happens not to be available. In its use one must remember that, weight for weight, it is less efficient than caustic soda, so that for every pound of the latter there must be employed 1.4 pounds of caustic potash. Like caustic soda, it must be guaranteed at least 85 per cent pure.

Lye.—This is a term employed to designate a grade of caustic soda put up primarily for domestic use, such as making soap from waste grease and for general cleansing. Since ordinary buyers of this grade of goods are not apt to be able to judge closely of its quality, it is sometimes of very inferior grade, though not necessarily so. If any guaranty regarding its purity can be obtained, it may be used for dip making, in case of necessity, in the same proportions as caustic soda.

THE GENERAL COMPOSITION OF DIPS.

All arsenical cattle dips contain arsenious oxid as the active tick-killing agent. But since straight arsenious oxid, that is, white arsenic, is so slightly and slowly soluble in water, it is necessary to use some other chemical agent, such as sodium carbonate or hydroxid, to bring the arsenious oxid into solution. In this way the white arsenic is changed to sodium arsenite if either sodium hydroxid or sodium carbonate is employed, or to potassium arsenite if the corresponding potassium compounds are used. Starting with a given weight of white arsenic, whether it is converted to sodium arsenite or to potassium arsenite appears to make no difference in the action of the finished dip.

After the white arsenic has been brought into solution, a variety of substances, such as tar, soap, oils, etc., may be added with one or more of the following objects in view: (1) To increase the effectiveness of the bath against ticks, either through greater penetrating power or better adhesion, or through repellent action; (2) to render milder the effect of the bath upon cattle; (3) to denature the bath so that cattle will not drink it. Proprietary concentrated dips differ from each other and from home-made dips essentially only in the nature and amount of such added substances.

MAKING THE BOILED DIP.

The boiled dip has been recommended for use in two strengths, the baths corresponding to which will be termed here "low-strength bath" and "high-strength bath." The low-strength bath is commonly used for ordinary tick-eradication work on the range, the cattle being dipped regularly every two weeks for possibly several months. The high-strength bath is used to treat cattle which are undergoing transportation to a tick-free region, the treatment being usually limited to only two dippings, 5 to 10 days apart.

To make 500 [1] gallons low-strength bath provide:

Sal soda [2]	24 pounds.
White arsenic, 99 per cent pure, in fine powder	8 pounds.
Pine tar	1 gallon.

Put 25 gallons of water in a kettle or tank of 40 to 50 gallons capacity, heat to boiling, and add the sal soda. When this has dissolved add the white arsenic, then boil and stir for 15 minutes or longer, until the white arsenic has entirely disappeared. If intended for immediate use cool to 140° F. (by the addition of cold water if desired), then pour in the pine tar in a thin stream while constantly and vigorously stirring the solution. Immediately empty the liquid into the dipping vat, which has already been three-fourths filled with water, and stir thoroughly.

For a stock solution to be kept on hand and used when needed, add no tar, but, after the solution of arsenic and soda has become entirely cold, make it up to 25 gallons (see method on page 7), stir well, let settle, and draw off into containers which can be well closed. This constitutes "low-strength boiled arsenic stock," and its use in a diluted dipping bath calls for a "tar stock," the preparation of which is described on page 7.

High-strength bath or high-strength boiled arsenic stock is prepared in exactly the same way, except that for 500 gallons of diluted bath there is used 10 pounds of white arsenic and 25 pounds of sal soda (or 11 pounds monohydrated sodium carbonate).

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[1] The number of pounds of white arsenic needed to make any number of gallons of bath of any strength may be obtained from Table 1, on page 11.

[2] Or monohydrated sodium carbonate, 10½ pounds.

A by-product of the action of sodium carbonate on white arsenic is the gas carbon dioxid. The escape of this gas is attended by considerable foaming of the solution, so the kettle must be generously large, and the operation of boiling must have constant watching to prevent the liquid from frothing over the edge of the kettle.

The kettle or tank, utensils, and materials must be perfectly free from all greasy or oily substances, since a small quantity of such matter is sufficient to form a coating over the arsenic and thus to prevent or delay its solution.

The boiled dip may be made perfectly well with very hard water, but, in that case, some residue of a fine white or gray powder will be left undissolved after boiling. This residue carries no arsenic, but arises from the action of the sodium carbonate upon compounds, chiefly of lime, in the water. Examination of the liquid after boiling for a few minutes with the soda before the arsenic has been added will show how much residue may be expected from this source.

MAKING THE S-B DIP.[1]

The S–B arsenical dip was developed by the present writer about two years ago to meet certain drawbacks to the boiled dip, namely, (1) the necessity for boiling large amounts of liquid, and (2) the impossibility of preparing highly concentrated stock solutions. Bureau employees in the field have given the preparation a thorough test in practical dipping. The difference between the S–B dip and the boiled dip is merely in the formulas and methods of preparation, the composition of the diluted baths used for dipping being practically the same in both cases.

The S–B dip is prepared in two parts which must not be mixed except in the diluted dipping bath, (1) arsenic stock, (2) tar stock.

S–B arsenic stock requires the following materials ready to hand before starting:

	Pounds.
Caustic soda,[2] at least 85 per cent pure, dry, granulated	4
White arsenic, 99 per cent pure, in fine powder	10
Sal soda,[3] crystals	10

In a 5-gallon kettle or metal[4] pail place the 4 pounds of caustic soda, add 1 gallon of cold water, and stir with a stick until the caustic soda is practically all dissolved. Without delay begin adding the white arsenic, in portions of a pound or two at a time, as fast as it can be dissolved without causing the solution to boil, stirring all the time. If the liquid begins to boil, stop stirring and let it cool slightly before adding more arsenic. The secret of success is to work in the arsenic fast enough to keep the solution very hot—nearly but not

[1] Abbreviated from "self-boiled," the name being suggested by the fact that the heat necessary to prepare the dip is wholly derived from chemical action between the raw materials.

[2] Or 5⅓ pounds dry caustic potash of equal purity.

[3] Or 4⅓ pounds monohydrated sodium carbonate.

[4] The chemicals employed have no effect upon iron. They will, however, actively corrode zinc, tin, or solder; hence a soldered pail must be watched for leaks and is far inferior to a seamless pail, stamped from a single sheet of iron. A tinned pail is preferred to a galvanized one, but a plain iron seamless pail or an iron kettle should be obtained if possible.

quite at the boiling point. The result should be a clear solution, except for dirt. If the liquid persistently remains muddy or milky, it may be because the operation has been conducted so fast that much water has been boiled out and sodium arsenite is beginning to crystallize, so add another gallon of water and stir. If the solution does not then clear up, the caustic soda must have been very low grade, and the undissolved substance must be arsenic. In that case, put the kettle over the fire, heat nearly, but not quite, to boiling, and stir. As soon as the solution of arsenic is complete, dilute to about 4 gallons, add the sodium carbonate, and stir until dissolved.

CAUTIONS: It is necessary to avoid splashing. Hence never work hurriedly; stir deliberately and regularly; do not dump in the arsenic and sal soda, but carefully slide them in from a grocer's scoop held close to the side of the pail and to the surface of the liquid. Perform the whole operation in a well-ventilated place and avoid inhaling steam.

After the solution has become cold add water to make it to exactly 5 gallons,[1] mix well, let settle, and draw off into containers which can be tightly corked or otherwise closed. Jugs or demijohns are best, but tin cans will serve if occasionally inspected for leaks which may occur after a time through the action of the solution upon the solder of the can.

Tar stock appropriate for use with either S-B arsenic stock or boiled arsenic stock is prepared thus:

In a capacious metal pail dissolve three-fourths of a pound of dry caustic soda or concentrated lye (or 1 pound of dry caustic potash) in 1 quart of water, add 1 gallon of pine tar, and stir thoroughly with a wooden paddle until the mixture, which at first looks streaked and muddy, brightens to a uniform thick fluid somewhat resembling molasses. Test it by letting about a teaspoonful drip from the paddle into a glass of water (a glass fruit jar or a wide-mouth bottle will serve) and stirring thoroughly with a sliver of wood. It should mix perfectly with the water. Globules of tar which can be seen by looking at the glass from underneath and which can not be blended with the water by repeated stirring indicate that more caustic-soda solution is needed. In that case make up more caustic-soda solution of the same strength and add it, not more than a pint at a time, and with thorough stirring, until the desired effect is produced.

If an appropriate glass vessel for making the test is not at hand, a little of the mixture may be taken between the fingers, then dip the fingers under water and try to rub off the tar. It should leave the fingers perfectly clean after a little rubbing with water. If an oily coating remains, more caustic-soda solution is needed. Such an extra addition of caustic soda will be required only in case of a very low-

[1] Best done by previously determining by measurement the depth of 5 gallons of water in the kettle. Set the kettle exactly level and mark the depth on a stick held vertically on the center of the bottom.

grade chemical or a very highly acid tar. The tar stock should be kept in closed containers, such as a pail with a friction top.

DILUTING THE DIP TO FORM A BATH.

Whatever the dip used, whether boiled dip, S–B dip, or a proprietary preparation,[1] certain facts must be borne in mind and a certain routine followed in preparing baths for dipping. All concentrated arsenical preparations are considerably heavier than water, and unless properly introduced into the dipping vat tend to make their way to the bottom, after which it is difficult to get an even mixture. In preparing a diluted bath it is necessary first to fill the vat with water, leaving just enough space below the full water line for the necessary volume of concentrated dip. Then the desired amount of concentrated dip is to be poured in a thin stream evenly all over the surface of the water—except, of course, at the shallow exit end of the vat—after which a few minutes of brisk stirring will make certain that the bath is of uniform strength throughout. If tar stock is used, as in the case of the S–B dip, the tar stock is to be added before the arsenic stock and may be put in when the vat is about three-fourths filled with water. Tar stock should always be mixed with two or three times its volume of water before being added to the vat.

The dilutions at which the various concentrated stocks will be used are as follows:

Boiled arsenic stock, containing either 8 pounds (low strength) or 10 pounds (high strength) white arsenic in 25 gallons, for the corresponding strength bath, 1 gallon added to every 19 gallons water ($2\frac{1}{8}$ pints to 5 gallons).

S–B arsenic stock, containing 10 pounds white arsenic in 5 gallons, for low-strength bath 1 gallon added to every 124 gallons water ($5\frac{1}{8}$ fluid ounces to 5 gallons); for high-strength bath add 1 gallon to every 99 gallons of water ($6\frac{1}{2}$ fluid ounces to 5 gallons).

Tar stock, for both low-strength and high-strength baths, 1 gallon added to every 300 gallons of finished bath (2 fluid ounces, or 4 tablespoonfuls, to 5 gallons). Mix the tar stock with two or three times its volume of water before adding to the vat. A certain latitude in the amount of tar stock used is permissible, but it is believed that the above proportions will be found most satisfactory.

REPLENISHING THE BATH AND CORRECTING ITS STRENGTH.

As dipping goes on, the bath will naturally need replenishing. In addition, its strength will probably need correction from time to time. The causes which may lead to changes in the strength of arsenical baths, together with methods

[1] It is very likely that the bureau will issue permission for certain proprietary preparations to be used in official dipping. Any such product will bear a statement on the label to the effect that the product has been examined by the bureau and has been permitted for use in official dipping at a given dilution.

of chemical analysis, have been elsewhere discussed by the writer.[1] Here it is sufficient to note that even if all precautions are taken against leakage, either in or out, against evaporation, and against mistakes in measurements, etc., still the bath is likely to change its strength owing to the action of microorganisms which grow therein in spite of the presence of the poisonous arsenic. As already mentioned, the active ingredient of the bath is an arsenite, either of sodium or potassium. One species of microorganism is able to take oxygen from the air and to combine it with the arsenite, thus forming an arsenate, a distinctly different compound of arsenic, and one which is much less poisonous to ticks. This species of microorganism appears to flourish in nearly all dipping baths under ordinary conditions of use and operates to gradually weaken the bath. There is, however, another species of microorganism which occasionally makes itself manifest in baths through which cattle are passed in exceptionally large numbers or at frequent intervals, and which operates in precisely the opposite manner, namely, to reduce any arsenate which may be present to arsenite, thus rendering the bath stronger.

The chemical analysis of arsenical baths with sufficient accuracy for practical purposes is not a difficult matter. It does, however, require some chemical training and equipment. If State officials concerned with dipping can not make provision for the execution of analyses, it should not be difficult to find someone—physician, veterinarian, pharmacist, instructor in school or college, or even a student—who, for a fee, which might be comparatively small if a sufficient number of samples from various sources could be counted on, would find it worth while to undertake this work. It is desirable to have the "actual arsenious oxid"—that is, the amount of arsenic existing as arsenite—determined at least once a month, and the "total arsenious oxid"—that is, the amount of arsenic existing as both arsenite and arsenate—determined at least every two months. To avoid danger of poisoning cattle, it is safer to discard the bath entirely whenever the "total arsenious oxid" would rise above 0.25 per cent for the low-strength bath or above 0.30 per cent for the high-strength bath after the bath had been adjusted to contain the proper amount of "actual arsenious oxid."

In taking samples for analysis certain precautions are necessary. First, the bath must be well stirred; next, the sample is filled at the vat side into the bottle in which it is to be sent to the analyst. The bottle should hold not less than 4 fluid ounces (one-fourth pint) and should be filled up to the neck. Unless the sample can be placed in the hands of the analyst in a very few hours it should be treated with formaldehyde to preserve it from the action of microorganisms which may affect the arsenic and which may work very rapidly in the sample after its removal from a comparatively cool location underground and exposure to hot summer weather. A little concentrated formaldehyde solution (37 per cent) may be cheaply obtained from the druggist, together with a medicine dropper. The formaldehyde is to be carefully added to the sample with the medicine dropper, in the proportion of exactly 5 drops to each 4 ounces of sample (20 drops to a pint). The bottle is then to be immediately corked, the cork and lip of bottle wiped dry and completely covered with melted sealing wax, rosin, or some similar material, in order to exclude air. A few matches will furnish the heat necessary for melting the sealing material. The analyst should be informed of exactly what steps were taken in preparing the samples, and the latter should be shipped to him without delay.

[1] Department of Agriculture Bulletin 76.

There are two methods of attacking the problems of replenishing a bath and of correcting its strength—(1) method by weight and (2) method by volume.

The method by weight.—This method bases all calculations upon the weight of white arsenic which actually is in the vat and the weight which ought to be in the vat. Table 1[1] gives the weight of white arsenic which is actually present in baths of various volumes and of varying percentages of arsenious oxid.

When the quantity of bath in the vat lies outside the range of the figures given in Table 1 it will only be necessary to multiply or to divide by 2. For example, if the bath amounts to 750 gallons it must evidently hold only half as much arsenic as if it amounted to 1,500 gallons. If, on the other hand, it is desired to more accurately employ figures which lie between those given in the table, either for volume of bath or for percentage or weight of arsenic, it is only necessary mentally to split the difference between the figures actually given.

The manner in which Table 1 is used may be illustrated as follows:

Suppose one needs to replenish and correct a bath which is contained in a vat holding 1,500 gallons to the full water line. He finds that he has in the vat 1,050 gallons of bath which his analyst informs him contains 0.14 per cent actual arsenious oxid. Looking up these figures in the table, he finds that they indicate 12¼ pounds of arsenious oxid in the vat. What he wants is a vat filled with solution of proper dipping strength, we will say, of the low-strength formula. Now, the low-strength formula calls for 0.19 per cent actual arsenious oxid, and, as before stated, his vat holds 1,500 gallons to the full water line. Looking up these figures in the table, he finds that his vat when filled with solution of proper strength must contain 23¾ pounds of arsenious oxid. Therefore, in filling his vat to the full water line he must introduce 23¾ less 12¼ pounds of white arsenic, or 11½ pounds.

Having found from Table 1 the weight of white arsenic necessary to add to the vat, subsequent procedure depends upon the kind of dip used. In the case of boiled dip prepared on the spot, it is simply necessary to weigh out the proper amount of arsenic and to boil it with the corresponding amount of sodium carbonate, water, etc. In case the low-strength boiled arsenic stock is to be employed, it is necessary to remember that it carries 1 pound of arsenious oxid in every 3⅛ gallons. Therefore, multiply the number of pounds of white arsenic needed by 3⅛ in order to find the number of gallons of low-strength boiled arsenic stock to be added. In case of the S-B arsenic stock, there is present 2 pounds of arsenious oxid in every gallon. Therefore, divide the number of pounds of white arsenic desired by 2 in order to obtain the corresponding number of gallons of S-B arsenic stock.

The high-strength boiled arsenic stock, of course, carries 1 pound of white arsenic in each 2½ gallons.

[1] Credit for this form of table is due to Dr. G. A. Handley, veterinary inspector in this bureau.

TABLE 1.—*Table for finding pounds of white arsenic in vat.*

Liquid in vat.	Per cent actual arsenious oxid in bath.															
	.10	.11	.12	.13	.14	.15	.16	.17	.18	.19[1]	.20	.21	.22	.23	.24[2]	.25
Gallons.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1,000.....	8¼	9	10	10¾	11½	12½	13¼	14	15	15¾	16½	17½	18¼	19	20	20¾
1,050.....	8¾	9½	10½	11¼	12¼	13	14	14¾	15¾	16½	17½	18¼	19¼	20	21	21¾
1,100.....	9¼	10	11	12	12¾	13¾	14½	15½	16½	17½	18¼	19¼	20	21	22	22¾
1,150.....	9½	10½	11½	12½	13½	14¼	15¼	16¼	17¼	18¼	19	20	21	22	23	24
1,200.....	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1,250.....	10¼	11½	12½	13½	14½	15½	16½	17¾	18¾	19¾	20¾	21¾	22¾	24	25	26
1,300.....	10¾	12	13	14	15	16¼	17¼	18¼	19½	20½	21½	22¾	23¾	24¾	26	27
1,350.....	11¼	12¼	13½	14½	15¾	16¾	18	19	20¼	21¼	22½	23½	24¾	25¾	27	28
1,400.....	11½	12¾	14	15	16¼	17½	18½	19¾	21	22	23¼	24½	25½	26¾	28	29
1,450.....	12	13¼	14½	15½	16¾	18	19¼	20½	21¾	23	24	25¼	26½	27¾	29	30
1,500.....	12½	13¾	15	16¼	17½	18¾	20	21¼	22½	23¾	25	26¼	27½	28¾	30	31¼
1,600.....	13¼	14½	16	17¼	18½	20	21¼	22½	24	25¼	26½	28	29¼	30½	32	33¼
1,700.....	14	15½	17	18¼	19¾	21¼	22½	24	25½	26¾	28¼	29½	31	32½	34	35¼
1,800.....	15	16½	18	19½	21	22½	24	25½	27	28½	30	31½	33	34½	36	37½
1,900.....	15¾	17¼	19	20½	22	23¾	25¼	26¾	28½	30	31½	33	34¾	36¼	38	39½
2,000.....	16½	18¼	20	21½	23¼	25	26½	28¼	30	31½	33¼	34¾	36½	38¼	40	41½

[1] This column may be taken as representing, nearly enough, correct weights of white arsenic for the low-strength bath.
[2] This column represents correct weights of white arsenic for the high-strength bath.

The method by volume.—This method naturally applies only to the use of stock solutions, not to cases where the desired amount of white arsenic is to be weighed out and dissolved on the spot. The facts needed to start on are exactly the same in both methods; that is, one must know the capacity of the vat at the full water line, the amount of bath actually in the vat, and its strength expressed as per cent of actual arsenious oxid. The problem really resolves itself into correcting the strength of the bath already in the vat, for when this has been done it is simply necessary to fill up the remaining space in the vat with bath of the regular strength. Calculations are simplified by the use of Table 2.

TABLE 2.—*Amount of arsenic stock necessary to correct each 100 gallons bath.*

Per cent actual arsenious oxid in bath.	For low-strength bath—		For high-strength bath—	
	Add low-strength boiled arsenic stock.	Add S-B arsenic stock.	Add high-strength boiled arsenic stock.	Add S-B arsenic stock.
Per cent.[1]	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
0.10	2.45	0.38	(1)	(1)
.11	2.18	.34	(1)	(1)
.12	1.91	.29	2.62	0.50
.13	1.64	.25	2.40	.46
.14	1.36	.21	2.18	.42
.15	1.09	.17	1.96	.38
.16	.82	.13	1.74	.34
.17	.55	.08	1.53	.29
.18	.27	.04	1.31	.25
.19	....	....	1.09	.21
.20	....	....	.87	.17
.21	....	....	.65	.13
.22	....	....	.44	.08
.23	....	....	.22	.04

[1] A bath less than half the desired strength should be discarded entirely.

To show the manner of using Table 2, the same example may be taken as served to illustrate Table 1, namely, a 1,500-gallon vat that contains 1,050 gallons of bath analyzing 0.14 per cent actual arsenious oxid, which is to be brought to the full water line with standard low-strength bath. Suppose that low-strength boiled arsenic stock is to be employed. From Table 2 it will be found that each 100 gallons of 0.14 per cent bath requires 1.36 gallons of low-strength boiled arsenic stock to bring it to the right strength, so for 1,050 gallons there is needed $10\frac{1}{2}\times1.36=14.28$ gallons of stock, which would bring the whole volume to $1{,}050+14=1{,}064$ gallons of proper strength bath. There is then left $1{,}500-1{,}064=436$ gallons of regular low-strength bath, which must also be introduced to fill the vat, for which there is, of course, needed 464÷20[1]=23.2 gallons of boiled arsenic stock. Now, $14.28+23.2=37.48$, or practically, $37\frac{1}{2}$ gallons of boiled arsenic stock altogether. Therefore water will be run into the vat, about 6 quarts of tar stock being added during the process as called for by the volume of fresh liquid introduced, finally leaving just enough room below the full water line for $37\frac{1}{2}$ gallons of low-strength boiled arsenic stock which is carefully measured in.

It appears not worth while to give a table for reducing baths if they are found by analysis to be too strong. This event but seldom occurs, and if it does the amount of water to be added may be easily calculated. If, for example, a bath analyzes 0.25 per cent actual arsenious oxid and is to be reduced to 0.19 per cent, then each 100 gallons should be diluted to make $100\times\frac{25}{19}=131\frac{1}{2}$ gallons—that is, $31\frac{1}{2}$ gallons of water must be added to each 100 gallons of bath in the vat.

OBTAINING THE CAPACITY OF A VAT.

To obtain the capacity of a dipping vat the following measurements must be taken: (1) Length of the bottom; (2) width of the bottom at its middle point; (3) length of water line; (4) width of water line at its middle point; (5) vertical depth of dip at middle of bottom—that is, at the same point where measurement No. 2 was taken. For future reference it is well to mark this point on the side of the vat. The measurements should be carried to the nearest inch for length, to the nearest half inch for depth, and to the nearest quarter inch for width.

The measurements taken in feet and inches are now to be reduced to feet and decimals of feet through Table 3.

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[1] See page 8.

TABLE 3.—*Equivalents of linear inches and decimals of 1 foot.*

Linear inches.	Decimal of 1 foot.	Linear inches.	Decimal of 1 foot.	Linear inches.	Decimal of 1 foot.
		4	0.33	8	0.67
1/4	0.02	4 1/4	.35	8 1/4	.69
1/2	.04	4 1/2	.38	8 1/2	.71
3/4	.06	4 3/4	.40	8 3/4	.73
1	.08	5	.42	9	.75
1 1/4	.10	5 1/4	.44	9 1/4	.77
1 1/2	.13	5 1/2	.46	9 1/2	.79
1 3/4	.15	5 3/4	.48	9 3/4	.81
2	.17	6	.50	10	.83
2 1/4	.19	6 1/4	.52	10 1/4	.85
2 1/2	.21	6 1/2	.54	10 1/2	.88
2 3/4	.23	6 3/4	.56	10 3/4	.90
3	.25	7	.58	11	.92
3 1/4	.27	7 1/4	.60	11 1/4	.94
3 1/2	.29	7 1/2	.63	11 1/2	.96
3 3/4	.31	7 3/4	.65	11 3/4	.98

There is an old, much-used rule for obtaining the capacity of a dipping vat which, though somewhat inaccurate, possesses the marked advantages of being easily grasped and, therefore, of not being liable to error in its application and of being readily worked out independently if partially forgotten. This approximate rule for present purposes may be stated as follows: *Multiply the average length by the average width, the product by the depth, and this product by $7\frac{1}{2}$.*[1] The average length is of course obtained by adding the bottom length to the water-line length and dividing the sum by 2; the average width is obtained in the same manner.

The rule may be thus expressed as a formula:

$$\frac{\text{top length} + \text{bottom length}}{2} \times \frac{\text{top width} + \text{bottom width}}{2} \times \text{depth} \times 7\tfrac{1}{2} =$$

approximate gallons capacity.

As previously noted, the results given by this rule or formula are not quite accurate. In fact, it does not account for the upper corners of the vat at the exit incline, and so the vat really holds somewhat more dip than thus calculated. The volume of this additional portion of the vat may be easily calculated after the following correction rule: *Multiply half the difference of the lengths by half the difference of the widths, the product by the depth, and this product by $2\frac{1}{2}$.*[2]

Expressed as a formula the correction becomes:

$$\frac{\text{top length} - \text{bottom length}}{2} \times \frac{\text{top width} - \text{bottom width}}{2} \times \text{depth} \times 2\tfrac{1}{2} =$$

additional gallons capacity.

[1] The precise figure is 7.48; that is, the number of gallons in one cubic foot.

[2] That is, by one-third of $7\frac{1}{2}$. Mathematically the correct order is to multiply by one-third the depth, then by $7\frac{1}{2}$. Practically, of course, the result is the same.

This correction, added to the approximate volume first found, gives the true capacity of the vat as nearly as it is possible to calculate it, though if the vat is unevenly constructed, no formula can be entirely accurate.

To illustrate the whole process of calculating the capacity of a vat, we will suppose that a vat has been constructed after the plans and specifications of the bureau elsewhere given. The measurements as taken, and as reduced to decimals through the use of Table 3, are the following:

Vat.	As taken.	Reduced to decimals.
	Ft. in.	*Ft.*
Bottom length	12 0	12.0
Bottom width	1 6	1.5
Water-line length	22 9	22.8
Water-line width	2 8½	2.71
Depth	5 3	5.25

In reducing to decimals, lengths need be carried only to the nearest tenth, but width and depth should be carried out to hundredths. Throughout subsequent calculations an accuracy greater than 1 per cent is unnecessary, hence decimal places should be cut off when multiplying so that each number multiplied, unless a whole number, shall contain not more than three figures.

Applying the approximate rule:

(1)	(2)	(3)	(4)	(5)
22.8	2.71	17.4	36.7	193
+12.0	+1.50	× 2.11	×5.25	× 7½
2) 34.8	2) 4.21	36.714	192.675	1,448 gallons, approximate capacity.
17.4	2.11			

Applying the correction:

(1)	(2)	(3)	(4)	(5)
22.8	2.71	5.4	3.29	17.3
−12.0	−1.50	× .61	×5.25	× 2½
2) 10.8	2) 1.21	3.294	17.2725	43.3 gallons, correction.
5.4	.61			

The correct figure for the capacity of the vat is, therefore, 1,448+43=1,491 gallons.

CONSTRUCTING A MEASURING ROD FOR THE VAT.

In replenishing or strengthening dipping fluids it is frequently necessary to ascertain just how many gallons of fluid are contained in a partially filled vat. Taking the water-line measurements and then calculating the contents is inconvenient and may sometimes seriously delay dipping operations. Therefore it is desirable to construct a measuring rod which will give directly the number of gallons of liquid in the vat at any time. Of course such a rod may be grad-

uated by measuring successive known volumes of water into the vat and marking on the rod the depth of each known volume, but in many cases graduation through calculation may be more practicable.

The first step is to calculate the water-line measurements at half depth and then at three-quarter depth. A little consideration will show that the water-line measurements at half depth are exactly half-way between the bottom measurements and the water-line measurements of the completely filled vat; that is, they are the average of these two measurements, obtained by adding them together and dividing by two. In the same way the water-line measurements at three-quarter depth are the average of the water-line measurements at half depth and at full depth.

The second step is to calculate the capacity of the vat when filled to three-quarter depth. Then, having prepared a straight, smooth stick, 7 or 8 feet long and about 1½ inches square, lay off from one end (marked "bottom") the feet depth at the three-quarter level, and mark the point with a pencil line, also adding the figure for gallons capacity at that point.

Third, subtract the capacity at three-quarter depth from the capacity at full depth, point back to the left two decimal places in the remainder, and divide it into one-fourth of the actual full depth in feet. The quotient is the average number of feet increase in depth per 100 gallons liquid above the three-quarter level.

Fourth, subtract the actual capacity at the three-quarter level from the next even 100 gallons above that level and set this figure as the numerator of a fraction of which 100 is the denominator. By this fraction multiply the figure for feet per 100 gallons, obtained in the third operation. The product is the distance to be laid off on the rod above the three-quarter depth point to obtain the level of the next even 100 gallons above that point. By referring to Table 3, convert this distance to inches and lay it off on the rod with proper notation. Now, having obtained this point for an even 100 gallons, it is only necessary to continue therefrom, marking off the level of each succeeding 100 gallons by using the figure obtained for "depth per 100 gallons." The same figure can be used to obtain capacities only a short distance below the three-quarter level without serious error. But by a similar series of calculations it is possible to obtain the capacity at half depth, then the true average figure for feet per 100 gallons between half depth and three-quarter depth, and so to graduate the rod between those two levels.

The graduations are to be made permanent by saw cuts or notches, 50-gallon marks being interpolated if desired, and the corresponding figures are cut into the wood.

An example may make the whole operation clearer. Taking the vat already used to illustrate the method of obtaining total capacity (p. 14), we first make the following table of dimensions:

Vat.	At full depth.	At half depth.	At three-quarter-depth.
	Feet.	*Feet.*	*Feet.*
Water-line length	22.8	17.4	20.1
Water-line width	2.71	2.11	2.41
Bottom length	12.0	12.0	12.0
Bottom width	1.5	1.5	1.5
Depth	5.25	2.63	3.94

Second, we calculate the capacity at three-quarter depth (3.94 feet) to be 956 gallons. From Table 3, 0.94 foot is found to be equal to 11¼ inches; hence, at 3 feet 11¼ inches from the bottom end of the rod is made the mark for a capacity of 956 gallons.

Third, knowing the full capacity to be 1,491 gallons; 1,491—956=535 gallons, or 5.35 hundreds of gallons space in the vat between the three-quarter and full-depth levels, which corresponds to 5.25÷4=1.31 feet difference in depth; 1.31÷5.35=0.245 foot per 100 gallons.

Fourth, 1,000—956=44 gallons; $\frac{44}{100}\times 0.245=0.108$ foot, corresponding to 44 gallons. From Table 3, 0.108 foot=1¼ inches (nearly), so on the rod 1¼ inches above the mark for 956 gallons is made a mark for 1,000 gallons. Then, from the 1,000 gallons mark is measured off 0.245 foot=3 inches for 1,100 gallons; 2×0.245=0.49 foot=6 inches for 1,200 gallons, etc.

The graduations necessarily depart a little, though not much, from the true points for levels between the fixed points established by calculation. One may, if familiar with the process of "plotting," lay off these fixed points from depths on one axis and capacities on the other, and so construct the "curve" of the capacity of the vat.

THE SAFE DISPOSAL OF WASTE ARSENICAL BATHS.

Previous publications of the department have advised that when vats are emptied for cleaning, the waste dip should not be flowed over land or vegetation to which domestic animals have access, or from whence it may find its way into water supplies, but should preferably be run into a properly located pit protected by a fence.

Dalrymple and Kerr[1] have proposed to add slaked lime and copperas to waste dip in the vat in order to throw down arsenic in an insoluble form, thus allowing the overlying liquid, after settling, to be disposed of as if arsenic free. The method requires very thorough stirring in order that the difficultly soluble lime may produce the desired effect. Whether the necessary stirring can be accomplished in large vats with sufficient thoroughness to render the method reliable under practical conditions on a large scale may be questionable.

[1] Bulletin 132, Louisiana Agricultural Experiment Station, 1911. A brief detailed description of the method is given in Farmers' Bulletin 498 and in Bureau of Animal Industry Circular 207 of the U. S. Department of Agriculture.

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